Request for Initial Packet of Information: Research and Development for Next Generation Nuclear Physics Accelerator Facilities

Project Name: Innovative, High-energy, Magnetized Electron Cooling for an EIC
Date: November 29, 2018
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Abstract

Objectives of the Project:

To obtain very high luminosity in an electron ion collider, electron cooling of the ions is essential. Electron cooling at low energies is a well-developed technique that can be used to allow higher currents to be stored in the ion ring of the collider. Once at full energy, the ions will undergo intra-beam scattering that will expand the bunch and reduce the luminosity. Low-energy DC coolers cannot be used at the high energy of a new electron ion collider. Instead, a bunched-beam cooler can, in principle, be used to counteract this scattering and preserve the injected beam brightness. This will require the production and maintenance of very high charge, very small energy spread bunches that can overlap the ions in a cooler system. This proposal is designed to strongly advance the state-of-the-art in high energy electron cooling technology.

Project Description:

Cooling at high energy with bunched beams presents severe design challenges since the cooling simulations and the production and transport of high charge bunches are well beyond the state-of-the-art in cooler simulations, and accelerator design and fabrication. This proposal will look at the development of reliable simulation codes for designing a bunched beam cooler and several different methods for the production of the bright electron beams necessary for cooling the ion beams at 40 GeV and above with both short (as in JLEIC) and long (as in eRHIC) ion bunches. It will also look at the design of a magnetized DC cooler at an energy of over 4 MeV, higher than any that have been operated to date. It will also study the transport of high charge magnetized bunches necessary for strong hadron cooling.

Fermilab will design and performed experiment aimed at understanding the beam dynamics associated with high-charge magnetized beams and specifically explore the preservation of beam quality (including magnetization) over long transport distances. The laboratory experiments will be performed at the FAST/IOTA facility.

Potential Impact:

The goal of this project is to better understand the design of high energy electron cooling so that the risk of building an Electron-Ion Collider is greatly reduced. A side benefit is a better understanding of the transport and preservation of high brightness, high charge electron bunches in any accelerator. A high brightness, low energy electron storage ring might also be useful for other uses such as Compton backscattering of a laser to produce gamma rays for nuclear physics research.

Control Milestones for the project duration. Provide at least one milestone per quarter consisting of the following:

Year 1:

- 3 months: Specify experiment and evaluate diagnostics.
- 6 months: Beam dynamics simulation of the FAST injector with high charge magnetized beam.
- 9 months: Work with FNAL to certify large dynamic range diagnostic.
- 12 months: Measure halo and emittance of magnetized beam as a function of charge.

Year 2:

- 15 months: Install deflector cavity and magnet coils for straight merger test.
- 18 months: Test merger concept combining deflector and magnetic coil.
- 21 months: Characterize longitudinal phase space (LPS) of magnetized beam.
- 21 months: Explore, via numerical simulations, the magnetized-beam dynamics in a bending system (most likely using part of the IOTA ring) – depending on results and IOTA availability perform a preliminary experiment.
- 24 months: Produce final reports and papers.

Project Schedule

Task	Year 1						Year 2					
EIC-like magnetized beam @ FAST (simulation)												
Magnetized-beam experiment												
Halo investigation experiment (install + execute)												
Straight merger experiment (install + execute)												
LPS measurement												
Document findings (reports and papers)												

Summary of concerns/issues at project initiation

- Planned experiments and installations at FAST have to be scheduled and are subject to the facility availability and performances.
- A power supply for the deflecting cavity to be incorporated in the merger was identified at Fermilab and could be borrowed but no formal agreement has been worked out yet.